factory. Only one such difference calls for special remark. The uncorrected difference, Stand.–Groomb., for Groomb. 3709 is $+3''\cdot37$. The authors remark (footnote, p. 95) that Groombridge appears to have considered that 3707 and 3709 lie on the same parallel; for in every instance he has only one circle-reading for the two stars. All nearly contemporary evidence shows that 3709, the following and fainter star of the pair, must have been, in 1810, fully $3''$ north of Groomb. 3707. Consequently it would appear that the circle-readings in question refer exclusively to the brighter and preceding star.

A Simple Method of Obtaining an Approximate Solution of Kepler's Equation. By Arthur A. Rambaut, M.A., D.Sc., F.R.S.

In the *Monthly Notices*, vol. l. p. 301, I have described a method of solving Kepler's equation, viz.

$$m = u - e \sin u,$$

by means of a prolate trochoid.

Six years later the same method was described by Mr. Plummer in the *Monthly Notices*, vol. lvi. p. 317, but no question of priority need arise, as the principle of the method is 200 years older than either of us, being contained in the thirty-first proposition of the first book of Newton's *Principia*.

The object of the present note is to point out another way in which the solution may be very simply effected by the help of the involute of the circle.

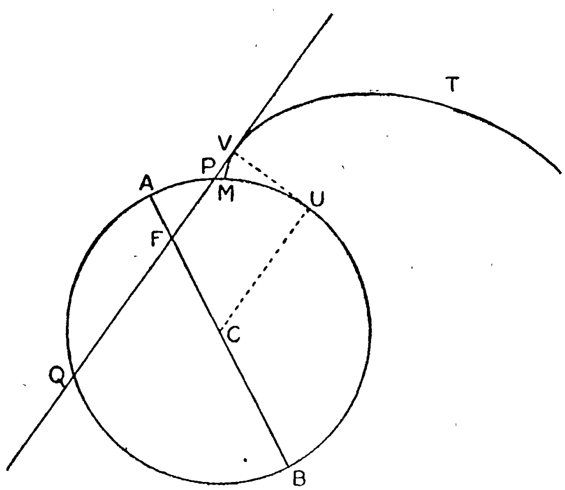


Fig. 1.

Let us take a circle, AMB, fig. 1, with centre C and any radius AC, and lay off the arc AM corresponding to the angle m. From M draw portion of the involute MVT, which can be done

very accurately by mechanical means. Divide AC at F so that $\frac{FC}{AC} = e$. From F draw a tangent to the involute at V cutting the circle in P and Q. Then the angle AFV $= u$.

For the normal to the involute at V touches the circle at U, where the radius CU is parallel to the tangent FV. But

$$AM = AU - MU = AU - VU = AU - FC \sin ACU,$$

or dividing by the radius,

$$m = ACU - \frac{FC}{AC} \sin ACU$$

Hence ACU $=$ AFV $= u$.

Now if the circle be graduated and numbered from 0° at A through P to 180° at B, and also from 0° at B through Q to 180° at A, the arcs AP and BQ may be read off directly, and we have

$$AU = \tfrac{1}{2}(AP + BQ)$$

Hence by taking the mean of the readings of the circle at the points P and Q, where it is cut by the tangent to the involute, we obtain the value of u. It may also be remarked that if u_0 is an approximate value of u thus obtained, and if m_0 be computed from the expression *

$$m_0 = u_0 - e \sin u_0$$

we have

$$\Delta u = \frac{m - m_0}{1 - e \cos u_0}$$

Δu being the correction of the first order required by u_0. But if the radius of the circle be taken as unity we have

$$FV = 1 - e \cos u_0$$

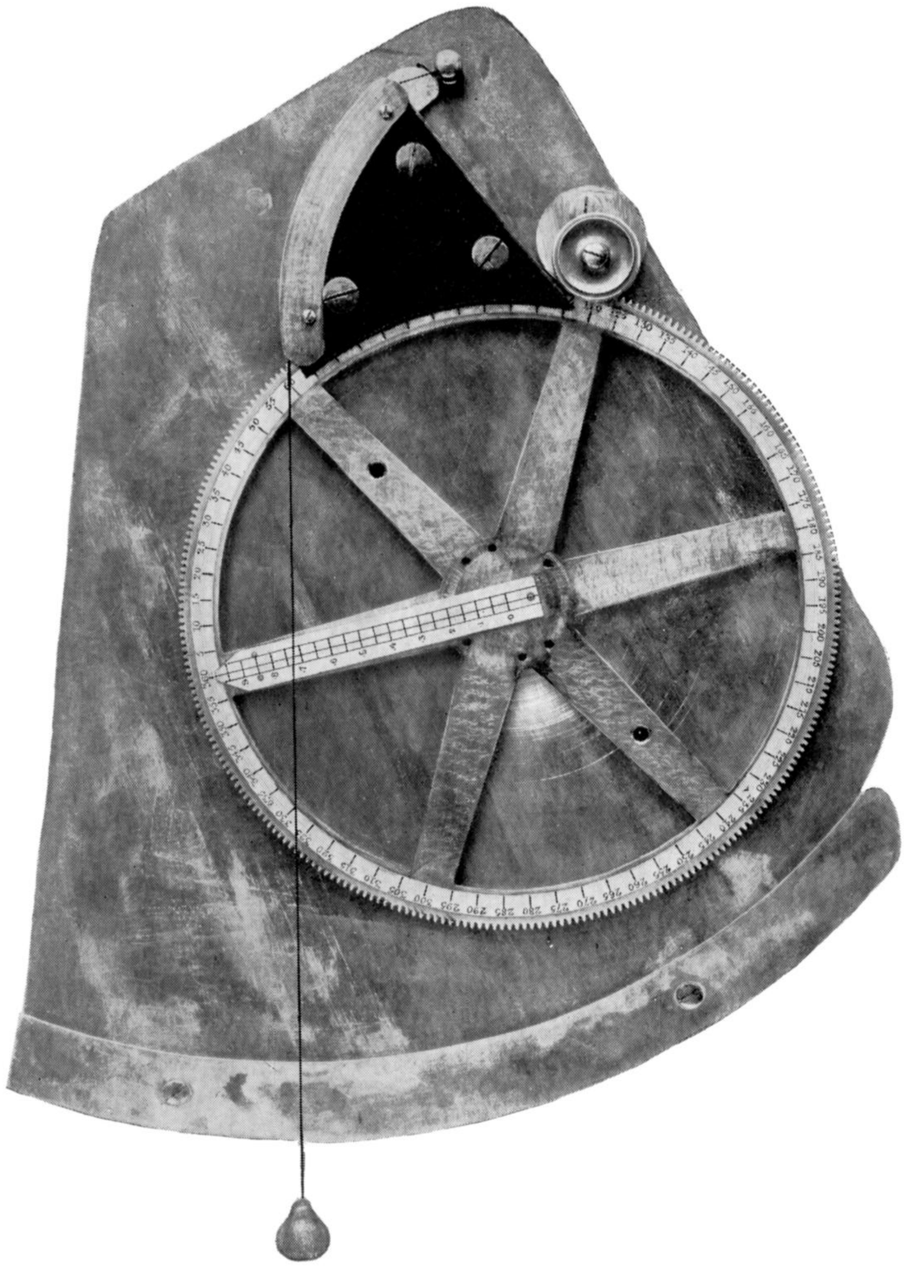
Hence

$$\Delta u = \frac{m - m_0}{FV}$$

Fig. 2 (Plate 2) is a reproduction of a photograph of a very simple instrument constructed on the above principle, by which the value of u may be obtained to within one-tenth of a degree in elliptic orbits of any eccentricity.

For this instrument I have adapted a small setting circle taken from the old "Jones" Meridian Circle of the Radcliffe Observatory. This circle is 5·5 inch in diameter, and is very neatly divided to half-degrees on silver. As the graduations are not numbered, as suggested above, but run continuously through

* Compare Dr. See's paper entitled "A General Method for Facilitating the Solution of Kepler's Equation by Mechanical Means," *Monthly Notices*, vol. lv. p. 425.



MECHANICAL SOLUTION OF KEPLER'S EQUATION. A. A. RAMBAUT.
FIG. 2.

360°, it is necessary to subtract 90° from the mean of the readings at P and Q in fig. 1.

The instrument has been constructed for me by a skilful watchmaker—Mr. H. Minn, of Oxford. The involute is cut out of a plate of ebonite, and seems to be very accurate in figure. The radius is divided to hundredths on a thin silvered plate screwed on to the face of the circle. The tangent is represented by a fine string winding around the involute, passing across the face of the circle and kept taut by a small weight which hangs over the edge of the brass plate, supported on three feet, which forms the base of the instrument.

With this apparatus a first approximation to u in ellipses of any eccentricity can be found with great rapidity. The advantages it seems to possess are: (1) the involute can be drawn very accurately by means of a string, or watch-spring, coiled round a cylinder; (2) a very small portion of the involute is required, only so much of it, in fact, as corresponds to a radian in the circle; (3) all angles are read off on the circle, which may be divided with any degree of accuracy required.

It would be unbecoming of me if in praise of this instrument I were to indulge in the enthusiastic language which Dr. See bestows on Waterson's Curve of Sines method (see *Monthly Notices*, vol. lvi. p. 54). I hope, however, that Dr. See may be induced to give this new method a trial, and in that case I shall be disappointed if he does not come to prefer it to any other.